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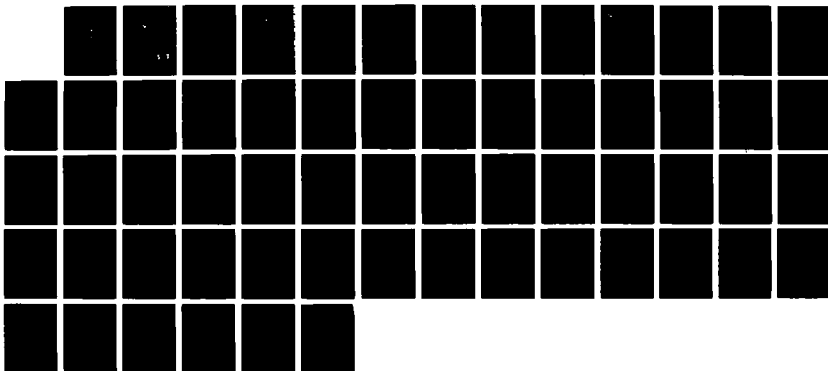
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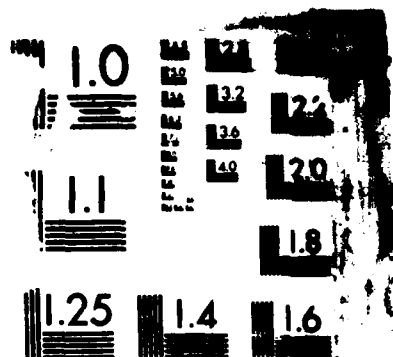
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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

EXPORT CONTROL IN DOD RESEARCH
ON STRUCTURAL MATERIALS

MAJOR STEVEN G. WAX

87-2670

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REPORT NUMBER 87-2670

TITLE EXPORT CONTROL IN DOD RESEARCH ON STRUCTURAL
MATERIALS

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Submitted to the faculty in partial fulfillment of
requirements for graduation.

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| 19. ABSTRACT (Continue on reverse if necessary and identify by block number) This study examined the interpretation and implementation of export control laws and regulations and their effect on DOD research on structural materials. It was determined that the DOD program managers responsible for making withholding decisions lack a working knowledge of the laws and directives governing those decisions, leading to inconsistent implementation and overly restrictive controls. Also, control of technologies was found to be generic, with entire technologies rather than specific aspects being controlled. The primary impact of these issues was on basic (6-1) research, universities in particular. The study recommended that guidelines consistent with the laws and directives be developed and consistently implemented. A proposed set of guidelines were developed in the study. In addition, specific rather than generic control of critical technologies was recommended. | | | | | |
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PREFACE

The past several years has seen a significant change in the approach to the control of research and technology. DOD now has in place a regulation that allows withholding of unclassified information from public release if it is militarily critical and subject to export control. Structural materials research, because of its importance to the U.S. Department of Defense, and thus to the Soviets, is one of the technical areas for which export controls and the withholding of unclassified information applies. There are, however, a significant number of issues related to the control of technical information which have yet to be resolved. These include questions such as whether technology should be controlled at all, whether research should be controlled, what specific areas of technology should be controlled, and the effect, if any, these have on the structural materials research community.

Having spent almost seven years as a program manager funding DOD research, the author is well aware of the delicate balance between giving away U.S. technology and stifling U.S. researchers through excessive control. With admitted bias, this author believes that structural materials research is of critical importance to DOD. Consequently, it is important to examine how the export regulations are interpreted and implemented specifically for that discipline, and perhaps more importantly, to assess whether this implementation and interpretation will have adverse effects on the field. Hopefully the conclusions and recommendations found in this study will ensure the continued productivity of structural materials research for DOD.

For their help in this study, the author would like to thank the following people: Dr. Ronald Kerber, Frank Sobieszczyk, Dr. Ben Wilcox, and the program managers and researchers who so graciously agreed to participate in the interviews. A special thanks goes, of course, to my wife Kathy and son Christopher, who put up with me during the effort -- especially to Kathy, who, having survived my dissertation, should not have had to put up with this again.

ABOUT THE AUTHOR

Major Wax received a B.S. in chemical engineering from the University of Massachusetts, Amherst MA in 1971. After commissioning in 1971, he attended the University of Illinois where he earned a M.S. in chemical engineering in 1973. His first active duty assignment was at the Air Force Rocket Propulsion Laboratory as a project engineer in the Satellite Propulsion Branch. Next, Major Wax attended Georgia Institute of Technology, Atlanta GA under AFIT sponsorship. After receiving his PhD in ceramic engineering in 1979, Major Wax was assigned to the Air Force Office of Scientific Research, Bolling AFB DC. There, as a program manager in the Electronic and Structural Materials Directorate he was responsible for Air Force basic research programs in ceramics and nondestructive evaluation. He also played an instrumental role in the establishment of major initiatives in spacecraft propulsion and power and spacecraft materials. His last assignment before attending Air Command and Staff College was as a program manager for the Defense Advance Research Projects Agency (DARPA). In that joint assignment, he was responsible for developing and managing a wide range of materials programs for all of the services. In addition, he was co-chairman of a committee on the materials requirements for the Strategic Defense Initiative, involved in developing materials requirements for the National Aerospace Plane, and chairman of the ceramics subcommittee of the White House Office of Science and Technology Policy's Committee on Materials.

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EXECUTIVE SUMMARY

Part of our College mission is distribution of the students' problem solving products to DoD sponsors and other interested agencies to enhance insight into contemporary, defense related issues. While the College has accepted this product as meeting academic requirements for graduation, the views and opinions expressed or implied are solely those of the author and should not be construed as carrying official sanction.

"insights into tomorrow"

REPORT NUMBER 87-2670

AUTHOR(S) MAJOR STEVEN G. WAX, USAF

TITLE EXPORT CONTROL IN DOD RESEARCH ON STRUCTURAL MATERIALS

I. Purpose: To examine the effect of the interpretation and implementation of export control regulations and directives on DOD research in structural materials.

II. Problem: The shift in the export control laws from protecting hardware to controlling technology has not been without controversy in the research community. Structural materials research, because of its significant impact on advanced DOD systems, is one of the research areas which has been thrust into the center of the issue. Yet, despite the importance of the issue, no examination of the impact of the export regulations on that research field has been accomplished. To do so requires answers to the following questions: Is there consistency in implementation? Does implementation follow the letter and/or the spirit of the law? Are there effects on the structural materials research community and if so, are these effects serious or long-term? And finally, are the controls serving their purpose or are they doing more harm than good? This study addresses those questions.

III. Approach: Those associated with research know it is virtually impossible to answer many of those questions in a quantitative fashion. Unbiased measurements of research quality are simply unavailable and quantitative statistics (number of patents, papers, etc) are subject to too many other variables

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(defense budget, system needs, etc). Consequently the approach chosen was to informally interview two categories of people; DOD program managers who make the implementation decisions, and researchers who ultimately must live with those decisions. These interviews allowed a series of conclusions to be formed concerning the implementation, interpretation and possible effects of export control on structural materials research. Although the sample sizes were small, the results could be validated by observing the representative nature of the program managers, by the consistency within and between the two groups and ultimately, by the consistency with the problems already recognized in the literature.

IV. Conclusions: The implementation and interpretation of export control as currently practiced is unlikely to have a drastically detrimental effect on structural materials research. There are, however, several issues which could affect that field. These include the lack of knowledge by the program managers of the directives and regulations which form the basis for withholding, overly restrictive control of the technology, and the generic approach used to control entire subject areas rather than specific information. The potential effect of these issues is significant.

It was found that basic research could be severely hindered by the overly restrictive interpretation of the directives and the generic approach to control. Universities especially could be kept out of areas of interest to DOD while professional societies might also be unnecessarily affected. In addition, certain technologies and/or companies could be hurt by the lack of communication with competitive foreign researchers. Finally, DOD's inconsistency in implementation and interpretation could lead to an alienation of the basic research community.

V Recommendations: The following recommendations resulted from this study:

1. Guidelines for control of structural materials research which are consistent with existing regulations and directives should be developed. It is especially critical that a policy for basic (6.1) and university research be addressed. The guidelines and policies should be implemented consistently throughout the field. It is expected that these would be less restrictive than those currently being used. Guidelines which meet these criteria are proposed in the study.

2. It is important that those parts of each technology which

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should be subject to controls are clearly identified and that only those parts are then controlled. Entire technologies should not be restricted.

3. It is essential that program managers and others making decisions about the withholding of technical information be educated. They must be aware of the rules and regulations regarding export control, the withholding of unclassified information, and the procedure and ramifications of filing a foreign patent. The current state of knowledge is completely unacceptable.

Chapter One

INTRODUCTION

Advances in science and technology have traditionally thrived in an atmosphere of open communication; openness has contributed to American military and economic strength and has been a tenet of American culture and higher education. However, recent trends, including apparent increases in acquisition efforts by our adversaries, have raised serious concerns that openness may harm U.S. security by providing adversaries with militarily relevant technology that can be directed against us. As would be expected when major national interests are in question, signs of distrust have appeared on all sides of the growing public discussion. The federal government, through its research and development agencies, and the university research community, where most basic research is conducted, both will lose much if the nation cannot find a policy course that reflects legitimate concerns. (3:v)

This quote by Frank Press, President of the National Academy of Sciences, reflects the growing controversy regarding the application of the export control regulations to DOD research, and the restrictions to scientific freedom which that application implies. One of those target technologies which our adversaries have coveted is structural materials research. (15:1-9) This is understandable because the utility to the Department of Defense of sophisticated advanced structural materials has been continually demonstrated. In fact, it is often the introduction of new materials into DOD systems which has made the significant difference in performance. Lightweight metals and composites for airplane structures, superalloys for high temperature turbines, higher performing armor materials, and ablative carbon for nose cones are just a few examples. It is reasonable to assume that continued research into such areas as new polymers, metals, ceramics, and composites will provide DOD with even more exciting advances in system capabilities. Yet, the success of this research depends on more than just a strong research budget. Equally important is a strong and

vibrant research community from which come the required technical breakthroughs. This makes restriction of the technology potentially damaging and makes the concerns of Dr. Press extremely relevant for structural materials research. In short, a "policy course" for handling the export control and withholding of structural materials research information must be found which will permit the free flow of scientific information, while at the same time, will keep critical technical data from the hands of the Soviets.

The purpose of this study is to examine the interpretation and implementation of export control regulations and directives on DOD research in structural materials. In other words, it will attempt to determine what the "policy course" for structural materials research is and whether it is serving the purpose. Specifically, this involves examining how the decisions to withhold unclassified technical information on structural materials research are made, what kinds of information are controlled, and what impact these controls might have on the ability of the structural research community to continue supporting DOD needs. In this context, "research" will be considered to include applied (6.2) and basic (6.1). (Note, 6.1 and 6.2 are shortened representations of budget categories for "basic research" and "exploratory development" respectively. The former tends to be generic, and is usually used for university efforts. An elaboration of this discussion of DOD 6.1 research can be found in a document on basic research published by the Office of the Secretary of Defense.) (14:--)

The 6.2 categories are more specific and are typical of the work service laboratories perform and fund. Both 6.1 and 6.2 research are critical to the advancement of structural materials capabilities.

There are two limitations to the scope of this topic. First, only research in the more traditional areas of material science (polymers, ceramics, metals, and composites) was examined. To consider additional areas (tribology, coatings, etc) would have made the topic intractable. Second, it is beyond the scope of this effort to be a definitive work on export control and its history. Both of those subjects have been addressed in a multitude of panels studies and papers.

Although not a definitive work on export control, some background is necessary in this study to equip the reader for a discussion of its application to structural materials research. Consequently, Chapter Two of this study will provide a brief background on the export control regulations and the DOD and National Security Directives which affect the withholding of unclassified information from the public. The issues for research in general are also presented. Chapter Three examines these issues specifically for structural materials research and presents the implementation of those directives and regulations

by program managers, as well as the issues associated with that implementation. A set of proposed guidelines for interpretation is also presented. Finally, the last chapter outlines the conclusions and recommendations from this study.

One final limitation needs to be discussed before beginning the main body of the study. The regulations and directives relating to export control, as can be expected for any controversial area, are extremely dynamic. Care was taken to avoid the use of references which were outdated. Even so, it is likely that many of the source documents used will be obsolete shortly after this writing. It is hoped, however, that the conclusions and recommendations of this study will remain useful, even if the specific details are subject to rapid change.

Chapter Two

BACKGROUND ON EXPORT CONTROL

HISTORY

Before the 1970's, export control had been used primarily as means of preventing the Soviets and their allies from getting high-tech hardware. The Arms Export Control Act of 1949 and the Export Administration Act of 1969 contained extensive control lists which essentially became a trade embargo against the Soviets. As the Cold War thawed, export control to the Warsaw Pact countries became less restrictive and ultimately became limited to arms. In the late 1970's, however, concern surfaced within DOD that public availability of critical technical information (e.g. publications, conference presentations) was eroding the lead of the U.S. in areas of military importance. (7:76-77) This led to the commission of a Defense Science Board Task Force on Export Control. The report issued by that task force, known as the "Bucy Report" after its chairman (J. Fred Bucy, President of Texas Instruments, Inc.) suggested that export control should "shift from focus on products to a focus on critical technology." (6:31) Among the most important findings was that "DOD should develop policy objectives and strategies for the control of key high technology fields ... including critical processes and key manufacturing equipment." (11:30) Thus, the Bucy Report helped "set in motion more vigorous attempts to apply export control regulations to transfer and dissemination of technical knowledge related to militarily useful technology." (24:8) The basic tenets of that report were incorporated into law by the Export Administration Act of 1979 and "arrays of design and manufacturing know-how" became subject to export control. (28:25) The Export Control Act already contained a provision to control "technical data" for National Security reasons. (20:12) Together these laws now made technology and technical know how subject to review before export.

It is important to note that information, once subject to export control, can be withheld from "Western" allies as well as the Soviet block. However, of equal importance is that just because export control applies does not mean export is prohibited; it simply means a license must be obtained in

accordance with the governing regulations. (These regulations will be discussed later in this chapter.) Nevertheless, there was a loophole in the law: information could be released in the U.S. publicly and thus be available to foreign governments even though the same information would be subject to review if exported. The serious implications for DOD research began early in the Reagan Administration when officials expressed increasing concern over the loss of unclassified information to the Soviets via the public domain loophole. Specifically, they felt defense related information was being disseminated by American scientists at professional conferences and through the publication of basic and applied research papers in the open scientific literature. (27:crs-1) This led DOD to begin monitoring the dissemination of technical information produced under DOD contract. In 1982, for example, over 150 papers about to be presented at the Society of Photo Optical Instrumentation Engineers were withdrawn after researchers were warned by DOD not to present them. (7:77) Shortly thereafter, Congress, sharing this concern, authorized DOD to withhold unclassified technical data if the data are under the possession or control of DOD, if the data have military or space application and, if such data may not be exported lawfully outside the U.S. without approval under the export control laws. This withholding authority would even protect the information from release under the Freedom of Information Act. (10:10)

INTERPRETATION FOR RESEARCH

From the Bucy Report to the Congressional Authorization, the U.S. export control policy made a significant shift from controlling hardware overseas to controlling technical data in the U.S. As one might expect, that shift in policy did not occur without significant controversy. Although other areas have been affected by this trend, the most vocal criticism (and the one of interest for this paper) was from scientists. They felt their right to freedom of speech was being violated by the development and interpretation of regulations which effectively would prevent them from publishing what they wanted, when they wanted. This controversy was not new. In the 1950's, scientists testified before Congress that technical secrecy is more detrimental than beneficial to U.S. security and implied that the U.S. had lost ground relative to our competitors. (24:6-7) In direct response to the Bucy Report and its aftermath, the National Academy of Science published a report on Scientific Communication and National Security. (3:--) The cover letter by Dr. Frank Press, President of the Academy, set the tone for the subject by noting that the report "addresses one of the most difficult policy issues: one in which fundamental national objectives seem to have been abruptly thrown into direct conflict." (3:v) In a continuation of that cover letter (Presented at the beginning of Chapter One.)

he eloquently captured the nature of the controversy.

Among the conclusions of the National Academy study was that restriction should not be applied to limit access or communication of basic or applied university research unless it involves a technology meeting all (their emphasis) of the following criteria:

The technology is developing rapidly, and the time from basic science to application is short. The technology has identifiable direct military application; or it is dual-use and involves process or production-related techniques. Transfer of the technology would give the U.S.S.R. a significant near-term military benefit. And, the U.S. is the only source of information about the technology, or other friendly nations that could also be the source have control systems as secure as ours. (3:5)

They also recommended that, if military products would rapidly result from the research, the research should be classified. But, the panel did allow that there are grey areas where the criteria are met, but classification is unwarranted. Here they suggested several agreements between DOD and the university which might be useful. However, the final conclusion of the report was that the export control regulations "should not be invoked to deal with the grey areas in government funded university research." (3:5) On the other hand, in 1982, a Defense Science Board Task Force on University Responsiveness to National Security found that "certain specific areas of university research, especially those conducted under DOD contract, are sensitive from an export control point-of-view." (17:4-2) Thus, notwithstanding the warnings of the scientific community, there was growing concern that the U.S was giving away technology.

Related to the technology loss was the controversy within DOD itself. (A good general discussion of this controversy can be found in a Naval War College thesis on export control.) (28:41-54) The Under Secretary of Defense for Policy believed strict controls were needed while, Richard DeLauer, Under Secretary of Defense for Research and Engineering felt differently. To this end, DeLauer drafted a policy which excluded fundamental research from withholding. (29:--)

Although DOD never approved the draft, Presidential Science Advisor George Keyworth intervened and endorsed DeLauer's approach. (7:79) Ultimately, the dialogue between Government and university research community since the 1982 Defense Sciences Board (DSB) report led to the policies contained in a National Security Decision Directive (NSDD 189) and to the general provisions and exclusions included in the current export control regulations. (24:8) If it were not for the intervention

of the Presidential Science Advisor, DOD's concern could have certainly led to interpretation of the "know-how" and "technical data" to encompass even the products of university researchers. This should be kept in mind as the current DOD procedures for withholding unclassified technical information are examined.

REGULATIONS FOR EXPORT CONTROL OF TECHNICAL DATA

As discussed above, DOD's authority to withhold unclassified information stems from Congressional authorization to deny public access to certain militarily critical information in order to prevent unlicensed export of that information. The procedures for withholding technical information from public dissemination as required in the DOD FY 84 Authorization Act are outlined in DOD Directive 5230.25 November 6, 1984 "Withholding of Unclassified Technical Data from Public Disclosure." (12:--) The primary policy is as follows:

(POLICY) ... the Secretary of Defense may withhold from public disclosure, notwithstanding any other provisions of the law, any technical data with military and space application in the possession of, or under the control of, the Department of Defense, if such data may not be exported lawfully without approval, authorization or license under E.O. 12470 ("Continuation of Export Control Regulations," March 30, 1984) or the Arms Control Act (Public Law 90-629 as amended). However, technical data may not be withheld under this section if regulations promulgated under either ... authorize the export of such data pursuant to a general, unrestricted license or exemption in such regulations. (12:3)

A DOD pamphlet (13:6) describes the process more simply by providing the conditions under which, if all are met, data may be withheld. These are:

1. are in possession of or under control of DOD.
2. have military or space application.
3. may not be lawfully exported under U.S. export laws.
4. disclose militarily critical technology.

The flow chart of Figure 1 is intended to outline this procedure. (Note: a DOD regulation is technically not applicable directly to the services. However, each service was required to put out its own regulation which implements that directive. Thus, the procedures in Figure 1 apply to all the defense departments.) The first two criteria are fairly

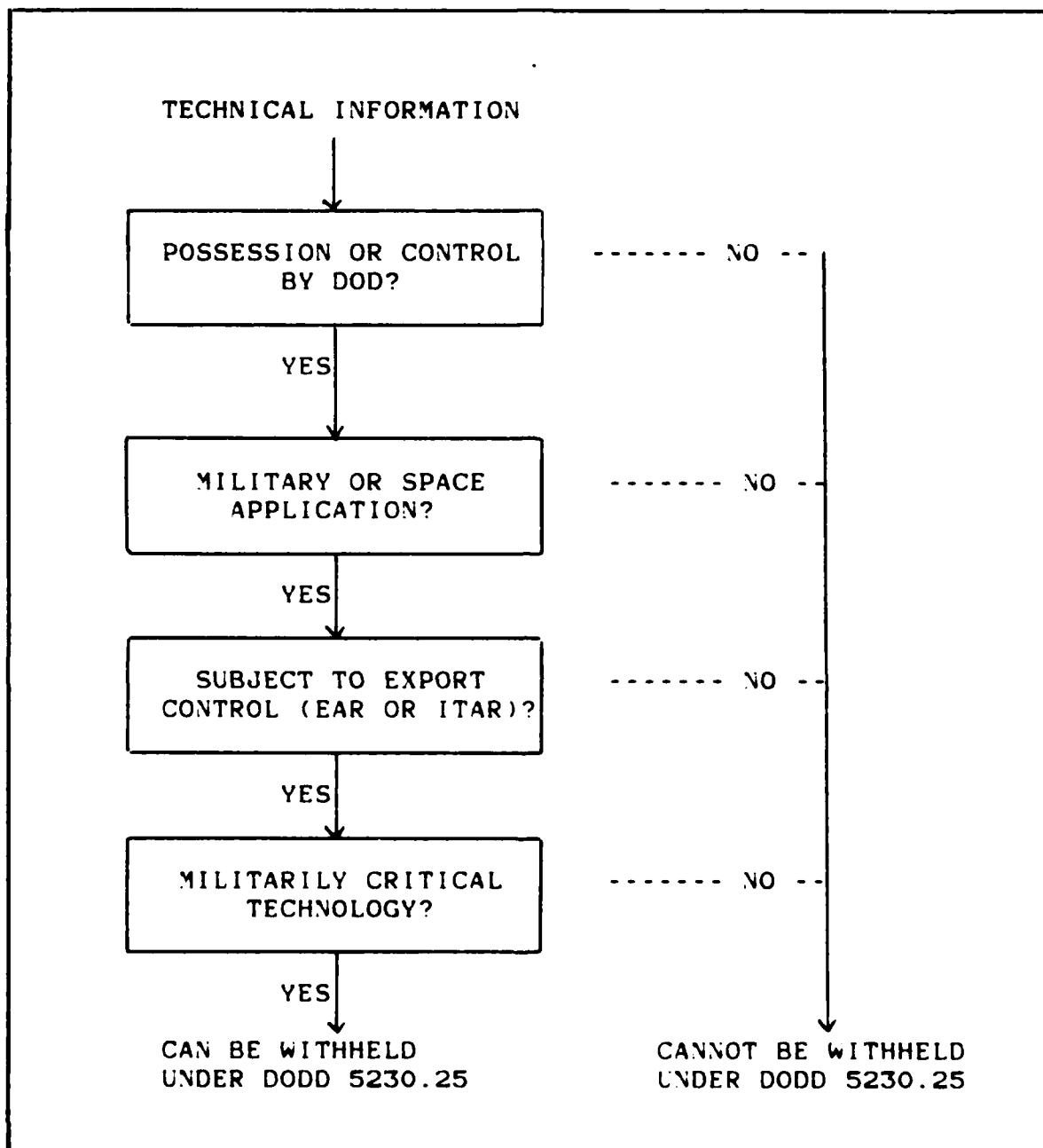


Figure 1. Flow Chart For Withholding Decision

straight forward. It is obvious when the information is controlled by DOD and almost all DOD work has military or space applications. However, it is the interpretation of the next two criteria which has led to the controversy. In order to make decisions regarding what may be withheld in any particular technology area, judgment must be made about how the U.S. export control laws relate to that technology area. This requires a familiarity with those laws and, perhaps more importantly, a knowledge of the general exemptions which may not be withheld under any circumstances. (Note: DODD 5230.25 provides the general exemptions.) Then, a decision as to whether the data is "critical" must be made. The directive suggests that the Military Critical Technologies List (MCTL) (16:--) "shall be used as general guidance." Space does not permit a detailed discussion of the U.S. export control laws and the lists which accompany them. Again, Delia Stoehr's Naval War College thesis is a good source of definitions and background. (28:9-21) However, a brief discussion of the various components of the laws is appropriate in order to set the stage for a discussion of the remaining controversy and ultimately of the application of export control to structural materials research.

The Arms Export Control Act is implemented by the Department of State through the International Traffic in Arms Regulations (ITAR). Essentially these contain the list of those defense related articles and services which are not to be exported without State Department approval, and procedures for applying for the export license. That list is called the U.S. Munitions List. In addition, information which is "directly related to the design, engineering, development, production, processing, manufacture, use, operation, overhaul, repair, maintenance, modification, or reconstruction of defense articles ... (or) ... enhances the state of the art of articles on the U.S. Munitions List" is included. (18:47682-47686) Although the scope of information covered is narrower than the EAA (see below), the controls are more far reaching with regard to technical data. (6:32) For example, the only exemptions to these regulations include information already in the public domain or information which has been approved for public release by an agency of the U.S. Government, and does not disclose "design, production, or manufacture of ... (items) on the U.S. Munitions List." (12:4-1)

The Export Administration Act (EAA), implemented by the Department of Commerce through a set of Export Administration Regulations (EAR), deals with the export of commodities. The Commodity Control List (CCL) includes those items which are determined to be subject to Department of Commerce export controls. In 1984, the CCL was expanded for national security reasons to include additional technical data and commodities. (19:12678) Much of the technical data as well as the added

commodities are directly relevant to structural materials. Similar to the ITAR, data generally available to the public is exempted. In addition, scientific or educational data is also authorized for export to all destinations as outlined below:

(1) Dissemination of information not directly and significantly related to design, production, or utilization in industrial processes, including such dissemination by correspondence, attendance at, or participation in, meeting; or

(2) Instruction at academic institutions and academic laboratories excluding information that involves research under contract related directly and significantly to design, production, or utilization in industrial processes." (12:3-1)

The Militarily Critical Technologies List (MCTL) is a list of critical technologies which discuss: arrays of know-how, keystone equipment, keystone materials, and goods accompanied by sophisticated know-how. (16:iii) The list is published in both classified (SECRET) and unclassified form, with the unclassified version leaving out the tying of the know-how to applications and the importance of that know-how. Unlike the CCL and the Munitions List, the MCTL is not an approved list for export control. It was developed by DOD to serve as guidance about what is militarily critical. However, this list is often used for considering updates of the other lists and might be considered more current than the others. There had been discussion of developing another list, that of rapidly emerging technologies, but this has been discarded by DOD for the present. (30:--)

Since technical data or information relating to "research" is the focus of this report, one other document needs to be examined. On September 25, 1985, National Security Decision Directive 189 "National Policy on the Transfer of Scientific, Technical and Engineering Information" (26:--) was signed by President Reagan. A copy of this directive may be found in Appendix A. The background behind this directive was the controversy surrounding the withholding of research information presented in the previous section. The directive states: "the mechanism for control of federally funded fundamental research in science, technology, and engineering at colleges, universities, and laboratories is classification" and that "no restrictions may be placed upon the conduct or reporting" of such research if it is not classified unless control is provided in U.S. Statutes. An interesting definition of "fundamental research" is also provided as:

basic and applied research ... the result of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons. (26:--)

UNRESOLVED ISSUES

Despite all of the discussions which led to the directives described above, significant unresolved issues remain regarding the withholding of technology. These include whether technology should be controlled at all, whether research should be controlled, what specific areas of technology should be controlled, and the effect these have on the research community. The purpose of this section is not to resolve those issues, but rather to discuss them in the general context of export control. Later, these issues will again be addressed in the specific context of materials science research.

Naturally, the first and foremost issue remaining is whether technology, especially research, should be withheld in the first place. One of the most vocal sources of disagreement with this policy was a recent study Securing Technological Advantage: Balancing Export Control and Innovation by the Center for Strategic and International Studies (CSIS) a "usually supportive think tank." (5:46) That study asserted that DOD's technical transfer policies ignore the need for free access to information and scientific exchange especially among the U.S., Japan and Europe. The report goes on to say "... growth of U.S. high technology industries depends on their having access to Western markets and technologies. Their competitiveness in these markets is highly sensitive to delays in export approvals and restrictions attached to those approvals." (2:42) In fact the central issue of that report is one which is still being asked: Can one stop technological flow to the Soviets without impeding the progress of our own technology base? Richard DeLauer had some strong feelings on this point. He noted that "To lock technology away for the purpose of protecting it, I think, is counterproductive. It will slowly disappear. When you open the safe some years later, you will find it is no longer there. It is dust." (9:7) Roland Schmidt, director of R&D for General Electric and Chairman of the National Science Board had said, "We have the stuff Russians want because of the effectiveness of our technological development, and this development can be severely impeded by regulatory overkill." (7:76) For the sake of fairness, it can be said that excellent arguments have been and continue to be made that control of technology

is necessary. The Report of the Technology Transfer Panel of the Committee on Armed Services (House of Representatives) stated that "removal of all barriers to West-West trade with regard to high technology trade would pose a serious threat to national security." (20:3) Also, Dr. Stephen Bryen, Deputy Assistant Secretary of Defense for International Economic Trade and Security Policy, responded to the CSIS study described above by saying that it was the "work of Defense industrialists" and "presents a narrow view, inaccurate and out of date ... does not reflect the work accomplished (by Bryen's office)." (5:46) Another interesting point is that the U.S. is one of the few nations that allows any research at all to be published when it is associated with or funded by its Defense Department. (30:--)

DeLauer himself was not entirely against control of technical data. His major concern was for fundamental research, and this he felt was adequately protected by National Security Decision Directive 189. (6:65) Likewise the recent amendment to the Export Administration Act (EAA) included the statement: "It is the policy of the United States to sustain vigorous scientific enterprise. To do so involves sustaining the ability of scientists and other scholars to freely communicate research findings ..." (4:38) It is also stated explicitly that university research "normally be considered fundamental research." (4:39) Taken together these two policies would appear to make fundamental research uncontrolled. However, points of contention remain because both of these contain caveats. NSDD 189 contains the phrase "unless control is provided in U.S. Statutes." Since the ITAR does not contain a provision for exempting fundamental research and since those regulations implement a U.S. Statute (Arms Export Control Act) they could be used to restrict fundamental data notwithstanding NSDD 189. In addition, the EAA contains a clause permitting fundamental research findings to be withheld "if a university or its researchers accept specific national security controls on a research project or activity sponsored by the U.S. government." What those "controls" are is still subject to debate. (4:39)

Even given a clear policy on "fundamental research", the definition of what is fundamental versus what is applied is not always clear. (21:134) Both NSDD 189 and the new EAA use the same definition. DOD however avoids those definitions and uses funding categories. According to an article in the Materials Research Bulletin in fall 1986, the Air Force has implemented a policy in which all unclassified academic work funded by 6.1 and 6.2 and all 6.1 work performed either within the laboratory or in industry can be shared without restriction. Non-university 6.2 efforts still remain subject to review and, the Air Force is to designate ahead of time to researchers when the controls will be in effect. Other DOD branches were said to have somewhat

tighter restrictions, but 6.1 still remains uncontrolled, and potential restrictions of 6.1 and 6.2 are put into the contracts ahead of time. (4:38) However, this could well lead to 6.2 work which fits the NSDD definition of but is still subject to controls. Also, the trend of university research away from the purely fundamental aspects of research toward more applied efforts caused Francis B. Kapper (a former Assistant Deputy of Defense, International Programs and Technology) to point out that even universities, as they increase their collaboration with industry, get more and more into technology desired by the Soviets. (8:12) Does this mean university research should be controlled? From the continued discussions being published, it is clear this issue, even for universities, is open.

Another key issue is the identification of the specific areas of technology that the laws and directives allow to be withheld. Even while agreeing that research might be subject to export controls, the Defense Science Board report also stated that there was a need for clear and concise guidelines for dissemination of technical information in DOD funded university research "which would not inhibit the flow of scientific information." (17:xvii) To that end, the Export Administration Act required DOD to develop a list of militarily critical technology which would be added to the CCL. DOD has developed such a list, the MCTL previously discussed. While this is the list DOD uses as guidance to make decisions about what is militarily critical, it has never been incorporated into the CCL and has no force of law. (7:77) Even the House Technology Transfer Panel noted that, while the MCTL was intended as a "set of militarily critical technologies that would be small in number and relatively stable over time", it has become "more of a generic document listing critical technologies." (20:8) Others have characterized it as "a list of all advanced technologies that can be applied to the development and manufacture of military systems." (24:5) Thus, there appears to be a serious question about whether a useful list of controlled technologies exists.

Finally, there are a group of related issues concerning how export control affects the functioning of the research community. The first area which comes to mind is the high concentration of foreign nationals working in research areas which are subject to export control. As Roland Schmidt noted, fifty percent of our engineering PhDs are foreign nationals, 40% are not permanent residents. He said that to exclude these people from technical exchange "is just extremely dangerous to R&D. It will always adversely affect our ability to develop new technology." (7:78) It has also been suggested that faculty who need to keep controlled research from their foreign graduate students, may utilize these documents less frequently, and thus reduce the value of academic teaching and research in those fields to which export control applies. (24:10) Another

possible problem is the threat of a boycott of their technology by NATO nations fed up with the U.S. position. (7:79) In areas in which the U.S. is behind, that could seriously affect U.S. research. Still another area of concern is that of patents. It has been suggested that the inability to publish certain technical data prevents or delays the publication of patents and thus jeopardizes U.S. interests. (24:6) And, last but not least, the most visible issue of all remains, that of the professional societies. Many of them have significant foreign membership and have either had to exclude foreign members from certain meetings or exclude discussion of the controlled areas of research.

Chapter Three

EXPORT CONTROL OF STRUCTURAL MATERIALS RESEARCH

ISSUES

As pointed out in the last chapter, there are many issues remaining concerning the export control of DOD research. It is fair to say that DOD research in structural materials is not exempt from these issues. In fact, of all the technical data potentially subject to controls, there are many reasons why this area has been among the most affected. First, many of the recent changes in export control regulations directly cite technical data related to structural materials. This is because structural materials are perhaps the best example of "dual-use" technology. Not only is structural materials research considered a necessity for improvements in military capability, but it is also of considerable importance for advancing nonmilitary products as well. As a corollary to this dual-use status, structural materials research is widely performed throughout the world, especially in Japan and Western Europe. This world wide interest complicates the export control situation since other countries share an interest in the U.S. technology and vice versa. Another complicating factor is the nature of the research itself. The problem with separating fundamental research from applied research is difficult enough with physics and chemistry. In structural materials, much of the research involves making tangible items. Since the export of many of these items is controlled, the control of the "research" to produce them must certainly be an issue. As one might expect, "Materials and Processing Technology" is one of the sections of the Militarily Critical Technologies List (MCTL). Thus, structural materials research is thrust at heart of the export control controversy.

Overlaid on the controversy described above, is the complicated structure of the DOD structural materials research community. There are over 15 DOD laboratories and agencies which fund and/or perform structural materials research. These organizations must make decisions on a number of different material systems, each of which is in a different stage of development. Furthermore, almost every major university in the U.S. teaches and performs research in structural materials with

the lines between DOD and civilian applications often blurred. In addition, there are over ten diverse and active professional societies associated with structural materials research, many with significant foreign membership. (31:--)

Because of the nature of materials research and the large number of individuals and groups which are involved in export control decisions, the effect these regulations could have on structural materials research is potentially large. Yet, no examination has been made of the implementation of export control to see if these potential complications are real. In other words, are the issues which seem to plague export control of research in general actually affecting the conduct of structural materials research? To answer this, one must answer a series of questions about export control and structural materials research. Is there consistency in implementation? Does implementation follow the letter and/or the spirit of the law? Are there effects on the structural materials research community and if so, are these effects serious or long-term? One might also ask whether the controls are serving their purpose or are they doing more harm than good? It is these issues which are addressed in the remainder of this study.

APPROACH

The goal is to determine if structural materials research has been to determine if it has or has not been affected by the implementation and interpretations of the controls on dissemination. It would be desirable in making this assessment to use unbiased, quantitative information to examine directly the quality of the research or its utility to DOD. Unfortunately, such quantitative information is not possible to develop. First, an unbiased measurement of the quality of on-going research is nonexistent. One measure of its effectiveness to DOD is its ultimate incorporation into DOD systems. Since, the application of controls to research is relatively new, it is unlikely this aspect is discernable yet. Other measures of the quality of research are far too subjective to be useful. Furthermore, quantitative statistics (number of patents, papers, amount of funding, who is participating in the work, etc.) are subject to so many other variables (defense budget, system needs, etc.) that these statistics would be meaningless.

What then would be meaningful? Obviously, qualitative estimates of the effects must be determined. The best and perhaps only source for this information is the structural materials research community itself. Consequently, the approach taken to develop the data base for this study was to informally interview two categories of people; DOD program managers who make the implementation decisions, and researchers who ultimately must live with those decisions. In order to make

this a tractable project, the number of program managers and their research areas had to be limited. For this project fourteen were queried. However, together these program managers represented all of the most common areas of structural materials (polymers, metals, ceramics and composites), all the DOD components and, both 6.1 and 6.2 research. In addition, many of the program managers had a supervisory position over three or more other program managers. Table 1 summarizes these details. Similarly, the number of researchers had to be limited. Again, they represented all the material systems and both university and industry. Table 1 summarizes these details as well. Although the sample size was small in both cases, this author believes the data obtained is quite representative. This will be discussed more fully in a later section.

IMPLEMENTATION AND INTERPRETATION

This section provides a summary of the interviews with the DOD program managers in structural materials research regarding their implementation of the withholding of unclassified information from public dissemination. It includes information on the program managers' knowledge of the laws and directives, how they interpret these laws and directives and, the guidelines the program managers use for making withholding decisions.

As discussed in Chapter Two, implementation is through DOD directive 5230.25 (or related service regulations) and requires a knowledge of the Export Administration Regulations (EAR), the International Traffic in Arms Regulations (ITAR) and how to use the Militarily Critical Technology List (MCTL). The first set of questions was therefore to establish the degree of familiarity the program managers had with these documents. The results tabulated in Table 2 were very surprising. Almost none of the program managers questioned were even aware there were directives which outlined the authority. Consequently, almost none were aware of the decision path which those directives prescribed. The only exceptions were program managers who had been involved in writing the DOD directive. In spite of this, all were aware that it was ITAR and EAR which were important, although the specific familiarity with these was certainly not substantial. Note that almost one third of the program managers were not familiar with what ITAR controlled while one half were not familiar with EAR. Their familiarity with the MCTL was not much better. Almost none were aware there was both an unclassified and classified version, while only slightly more than half had a working knowledge of what was contained in either version. In keeping with the statistics described above, with the exception of the few who used the MCTL, no program manager used any of these written directives or regulations to make decisions. Ironically, the only other written guideline used was a draft of a DOD guideline put out in Jan. 1984 by

PROGRAM MANAGERS

| <u>AGENCY REPRESENTED</u> | <u>PERCENT</u> | <u>MATERIAL SYSTEMS RESPONSIBLE FOR (1)</u> | <u>PERCENT</u> |
|-------------------------------|----------------|---|----------------|
| DARPA | 21 | POLYMERS | 21 |
| AIR FORCE | 36 | POLYMER COMPOSITES | 36 |
| NAVY | 21 | METALS | 57 |
| ARMY | 21 | METAL MATRIX COMPOSITES | 43 |
| | | CERAMICS | 57 |
| | | CERAMIC COMPOSITES | 57 |
| | | CARBON CARBON | 29 |

| <u>TYPE OF RESEARCH RESPONSIBILITY</u> | <u>PERCENT</u> | <u>PERCENT WITH SUPERVISORY RESPONSIBILITY</u> |
|--|----------------|--|
| BASIC (6.1) | 64 | |
| APPLIED (6.2) | 71 | 43 |

RESEARCHERS

| <u>MATERIAL SYSTEM OF RESEARCH (2)</u> | <u>PERCENT</u> | <u>AFFILIATION</u> | <u>PERCENT</u> |
|--|----------------|-----------------------------|----------------|
| POLYMERS | 14 | UNIVERSITY | 43 |
| POLYMER COMPOSITES | 14 | INDUSTRY | 57 |
| METALS | 57 | | |
| METAL COMPOSITES | 71 | <u>TYPE OF RESEARCH (2)</u> | <u>PERCENT</u> |
| CERAMICS | 29 | BASIC (6.1) | 57 |
| CERAMIC COMPOSITES | 29 | APPLIED (6.2) | 57 |
| CARBON CARBON | 29 | | |

PERCENT WITH SUPERVISORY RESPONSIBILITY 86

NOTES:

(1) MATERIAL SYSTEMS FOR WHICH EXPORT CONTROL DECISIONS ARE MADE

(2) PERFORMED UNDER DOD CONTRACT

Table 1. Background of Interviewed Program Managers and Researchers

Frank Kapper, formerly of OSD. (25:--) This draft was never actually approved. Based on the results described above, it can be seen that none of the program managers queried were really sure what the regulations and directives indicate should and should not be controlled.

| FAMILIARITY | PERCENT | | | | |
|---------------------|---------|-----|------|------------------------|----|
| | DODD(1) | EAR | ITAR | (2) MCTL(U) MCTL(S) | |
| UNAWARE/NEVER SEEN | 86 | 7 | 0 | 24 | 43 |
| AWARE NEVER READ | 0 | 43 | 29 | 14 | 7 |
| READ PARTS/FAMILIAR | 14 | 50 | 71 | 57 | 14 |
| USED FOR DECISIONS | 0 | 0 | 0 | 14 | 0 |

NOTES:

(1) DOD DIRECTIVE 5230.25 OR IMPLEMENTING SERVICE DIRECTIVES AS APPLICABLE.

(2) (U) AND (S) REFER TO THE UNCLASSIFIED AND CLASSIFIED VERSION OF THE MCTL RESPECTIVELY.

Table 2. Familiarity of Program Managers with Export Control Information

If the program managers do not use written guidelines, what do they use? Invariably the answer was that they used their personal familiarity with their field coupled with their perceptions of what should be withheld. This is not to say there were no general rules. For example, all the program managers felt information tied to a specific application should be controlled. Similarly, most agreed that generic property information should not be controlled unless it is tied to processing. At first glance, the most consistent response concerned "processing" information, which all of the program managers indicated they withhold. However, when explored further, this turned out to be far less consistent a response than it first appeared. Table 3 shows that, while about one

quarter of the program managers control any and all processing information, the other three quarters place various caveats on their control. As seen in that table, the caveats are wide ranging and make "processing" information actually one of the least predictable of all.

Another general area explored was the program managers approaches toward 6.1 and university research. Once again, there were significant differences. (See Table 4.) Note that for about half it made a difference whether the research was 6.1 or conducted at a University, but for the other half it did not. Only a few were aware of NSDD 189, and many of those still felt

| <u>APPROACH</u> | <u>PERCENT</u> |
|--|----------------|
| ALWAYS CONTROL PROCESSING | 29 |
| CONTROL SOMETIMES * | 71 |
| * TYPICAL CAVEATS -- <u>ONLY WHEN</u> : | |
| PRINCIPLES ARE DEVELOPED | |
| DETAILS ARE GIVEN | |
| UNIQUE PROCESSING SCIENCE IS GIVEN | |
| INFORMATION EXCEED STATE-OF-THE-ART IN THE WORLD | |
| INFORMATION WOULD BE PROPRIETARY | |

Table 3. Approach to Control of Processing Information

| | <u>HANDLING 6.1</u> | <u>UNIVERSITY</u> |
|---------------------|---------------------|-------------------|
| TREATED DIFFERENTLY | 50% | 45% |
| TREATED SAME | 50% | 55% |

Table 4. Approach to Control of Basic and University Research

University and/or 6.1 research had to be controlled if it met their perceptions of controllable technical data, regardless of the NSDD.

In summary, the implementation and interpretation of the export control laws to structural materials research was extremely inconsistent. Hardly any guidelines were used, with the decisions made almost entirely on the opinion of the program manager. University and 6.1 research were quite often not treated differently. Perhaps the most surprising statistic of all, however, was the significant lack of knowledge the program managers had about the contents of the various documents which provide the basis for the withholding procedure.

PROBLEMS RESULTING FROM IMPLEMENTATION

After the discussion of how export control laws are actually implemented and interpreted, it is now appropriate to examine what problems this implementation might cause for the structural materials community. Here the opinions of contractors as well as the DOD program managers were sought. No attempt has been made in this section to fix blame for the problems, i.e. to fault the contractors, program manager's implementation or the export regulations themselves. This is left for the next chapter. The intent here is to present, without comment, the opinions of those on both sides of DOD research in structural materials.

Surprisingly, despite the lack of specific knowledge about what can and cannot be controlled, the vast majority of the program managers indicated they had no difficulty in implementing the export control rules. Less than one third were bothered by the lack of guidelines and felt they personally were working in the dark. The situation was completely different when the program managers were asked whether they had observed any difficulties the contractors might be having with the export control laws. All of the program managers observed problems with the implementation of the export control laws, and well over half felt the major problem was the lack of consistency among the other program managers. Interestingly, while most program managers felt they could operate successfully in the ill-defined environment, most were equally sure other program managers could not. There was a strong feeling among program managers and researchers alike that the field was being over controlled. In fact, many of the program managers admitted that they were being conservative just to be on the safe side.

Although most prevalent, the inconsistency among program managers was not the only problem observed. Two other issues were raised frequently. The first was the loss of competitive edge with the other Western nations. Over half the program managers believed the export control laws applied to structural materials research were adversely affecting the interaction of U.S researchers and companies with foreign researchers and/or markets. They felt the current interpretation of the laws and

directives either made it difficult to utilize foreign technology by preventing joint programs or in some cases actually prevented U.S. companies from penetrating a foreign market. Many felt the restrictions were foolishly cutting off communication with countries where the technology was equal to or ahead of the U.S. One program manager even noted the difficulty in exporting data to a foreign country which, though taken in the U.S., was on a composite made in that foreign country. The second major issue, actually related to the first, was the filing of patents, especially foreign patents. There was a significant amount of confusion about how patent applications which contain "export controlled" information are treated. Many felt that foreign patents give away information which was otherwise being controlled in the U.S. Still others noted that, when "secrecy orders" (a restriction on the publication of the patent for security reasons) were put on patents, it prevented U.S. companies from claiming research breakthroughs before other competitive Western countries did. In one case a program manager had to intercede to have a foreign patent released so that the company could protect itself against competitive on-going European research. It is also fair to say that there was not a great deal of understanding of the patent review and/or the secrecy order process among the program managers.

Other issues surfaced, although less consistently. There was at least one instance where a university lost a contract (6.2 funds) because it refused to sign a blanket agreement to review all their work before publishing. In a similar manner, some researchers were known to be purposely avoiding research in controlled areas (e.g. composites). Others noted that the bureaucratic system required for approvals led to delays in the timeliness of research publications and presentations. This also led to program managers clearing abstracts for publication and hoping the paper is consistent with it. Finally, several program managers discussed how the professional societies were having a hard time handling the need to have "restricted" sessions when they have significant foreign membership.

The other, and perhaps equally interesting, source of issues was the research community itself. Primarily, these researchers were asked their opinion of how the controls were being implemented, and their assessment of the impact, if any, on materials science research. Although many of the comments were very specific and thus not appropriate for this general discussion, there were several themes which were consistent enough to be representative of the research community.

Not surprisingly, the most prevalent of such themes was the inconsistency of implementation. The researchers agreed completely with the program managers that there is simply no consistent set of guidelines being used by DOD to implement

export control. Many reported that the same information was sometimes withheld, and sometimes not, depending on who did the review. Most felt this made their job more difficult. Another issue raised which agreed with one brought out by the DOD program managers was foreign competition. Here, over half the researchers felt the restriction on technology transfer hurt smaller companies which were trying to break into the foreign market. The argument raised was that a foreign company would need to know how a material was made in order to have confidence in it, but that the U.S. companies were prohibited from providing that information. It is not clear whether this is as much an issue for research as it is for production, although in many of those small companies, the line is thin. Likewise, the researchers were as unclear about the patent process (i.e. what is controlled and why) as the program managers.

One other issue raised by half of the researchers was the inadequacy of the broad brush approach used for withholding technology and documents. This is of course related to the inconsistency described above, but is much deeper. It was noted that entire documents or even entire technologies tended to get "stamped" as subject to export control and from then on the generic technology area remains controlled. This means that if a contractor writes a 70 page report, there is no way for anyone to know if any of it is releasable unless a specific request is made to get a paper approved for public release. Many of the researchers as well as many of the program managers felt this eliminates the flow of a large body of scientific information which really should be uncontrolled. The opinion was expressed that NSDD 189 put the burden on the Government to show a need for control, but that the reverse was actually the case.

In addition to the general comments above, the university community had some specific problems. There were several among those asked who felt that the university community was being "fenced" off from the rest of the research community. In fact, universities which desire to publish cannot participate in many of the important areas of structural materials research such as processing. One researcher actually had to change the material system to a "generic" and "uninteresting" system to avoid being unable to publish. This tends to perpetuate the feeling that universities do not do relevant research. This also presented problems when dealing with foreign graduate students.

One last question which was asked of both program managers and researchers was their general opinion of the system as a whole. Almost all those questioned felt control was necessary to keep U.S. technology from going to the Soviets. However, more than half of the respondents did not feel the system in place was worth the effort. There was a clear consensus that information was available in the other Western countries of equal use to the East, and that the U.S. was really hurting

itself. One researcher noted that the U.S. was now cutting off flow of structural materials research to Japan and the European countries just as they are beginning to surpass some of our capabilities and could be of use to us. This now gives the foreign researchers an excuse not to share their advanced technology with us. Even so, many felt the system worked as well as could be expected given the inconsistencies in interpretation. It is safe to say, no one felt that export control applied to structural materials research has been or will be catastrophic.

SUMMARY OF FINDINGS

The informal interviews with DOD program managers and researchers have resulted in the elucidation of how export control is implemented for research in structural materials, and has established several issues and problems relating to that implementation. These are summarized in Table 5.

VALIDITY OF FINDINGS

In order to ensure the finding presented in Table 5 are useful for drawing conclusions about how export control relates to structural materials, it is necessary to ensure that these opinions are representative. Although the number of program managers questioned was small (fourteen), there are several reasons why the author believes they are valid. First, it is possible to examine the data statistically and remain convinced the data are still useful. This is done by making the questions binomial (i.e. yes or no answers) and then, using the results of the study as the estimated mean, a confidence level can be estimated. (1:167) For example, if 86% of the program managers have not read either the DOD or service directives regarding export control, then one can be 90% sure that at least 44% of the program managers have not read them. Likewise if none of the fourteen use any of the laws or regulations in making control decisions, it is unlikely (90%) that any more than 38% of all program managers would use them. In other words, the quantitative results were so one sided in most cases, one can be reasonably sure they are representative.

However, there is still another, even more convincing argument that gives credibility to the study's results. As discussed in Chapter Three, the program managers interviewed represent a significant portion of the funding responsibility of all the structural materials research funded by DOD. This can be best shown if the data in Table 1 is rearranged as shown in Table 6. This table clearly demonstrates that almost all of the major DOD efforts in structural materials research are well represented. Thus, what is done by those interviewed is very representative of what the structural materials research

1. Almost none of the DOD program managers interviewed were knowledgeable about the specifics of the DOD directive and the export control regulations that govern the withholding of unclassified technical information.
2. Almost all the DOD program managers interviewed used personal knowledge rather than written guidelines to make withholding decisions. Although a few used the MCTL, most of those familiar with this document felt it was useless as a decision tool.
3. Most DOD program managers felt comfortable with their own idea about what can and cannot be withheld, but almost half felt there were significant inconsistencies in the implementation of withholding by other program managers. The researchers agreed that the consistency of implementation was poor.
4. Half of the program managers did not differentiate between university or 6.1 and other classes of technical information when making export control decisions.
5. Many DOD program managers felt that interaction with foreign researchers and markets was being hurt. This agreed with the opinions of the researchers.
6. Some DOD program managers felt that foreign patents filed by U.S. companies gave away information otherwise controlled, while others felt control of foreign patents hurt U.S. efforts to achieve foreign markets.
7. Researchers, especially those at the universities, had trouble with the generic approach which tended to place research areas into "controlled" and "uncontrolled" categories without regard to the specifics of the information. This forced universities away from "interesting" areas and was considered one of the major stumbling blocks to much of the interaction among the research community. Many DOD program managers noted this as well.

Table 5. Significant Findings

| <u>SERVICE</u> | <u>6.1</u> | <u>6.2</u> |
|----------------|------------|------------|
| DARPA | S | S |
| AIR FORCE | S | X |
| NAVY | S | X |
| ARMY | S | S |

S = SIGNIFICANT PORTION OF PROGRAM REPRESENTED BY INTERVIEWS
X = SOME REPRESENTATION

Table 6. Extent of Major DOD Programs Covered by Interviews

community experiences. The same case cannot be made for the handful of researchers interviewed; the DOD research efforts are too broadly dispersed to make a small sample representative. However, the findings represent researcher's responses only when they were self consistent and/or consistent with the major issues raised by the DOD program managers. For example, both groups felt there were difficulties relating to other Western countries' researchers, and both felt the research was being over controlled.

Perhaps adding the most credibility of all was the excellent agreement between the issues raised for structural materials research in particular and the general unresolved issues outlined in Chapter Two. First, structural materials research seems to suffer from the same lack of guidelines which the DSB report warned against. (17:viii) Also, those involved in structural materials research seemed to agree with others (20:8) that the MCTL was useless. Furthermore, difficulties were noted, as expected, in professional society conferences. However, the most critical similarity was the control over basic research and university research which appeared to be in violation of NSDD 189. This was one of the most generic problems that scientists raised. (See Chapter Two.)

Thus, it seems reasonable to assume the issues and problems described in Table 5 are representative of the issues and problems facing the field of structural materials research due to the implementation of export control.

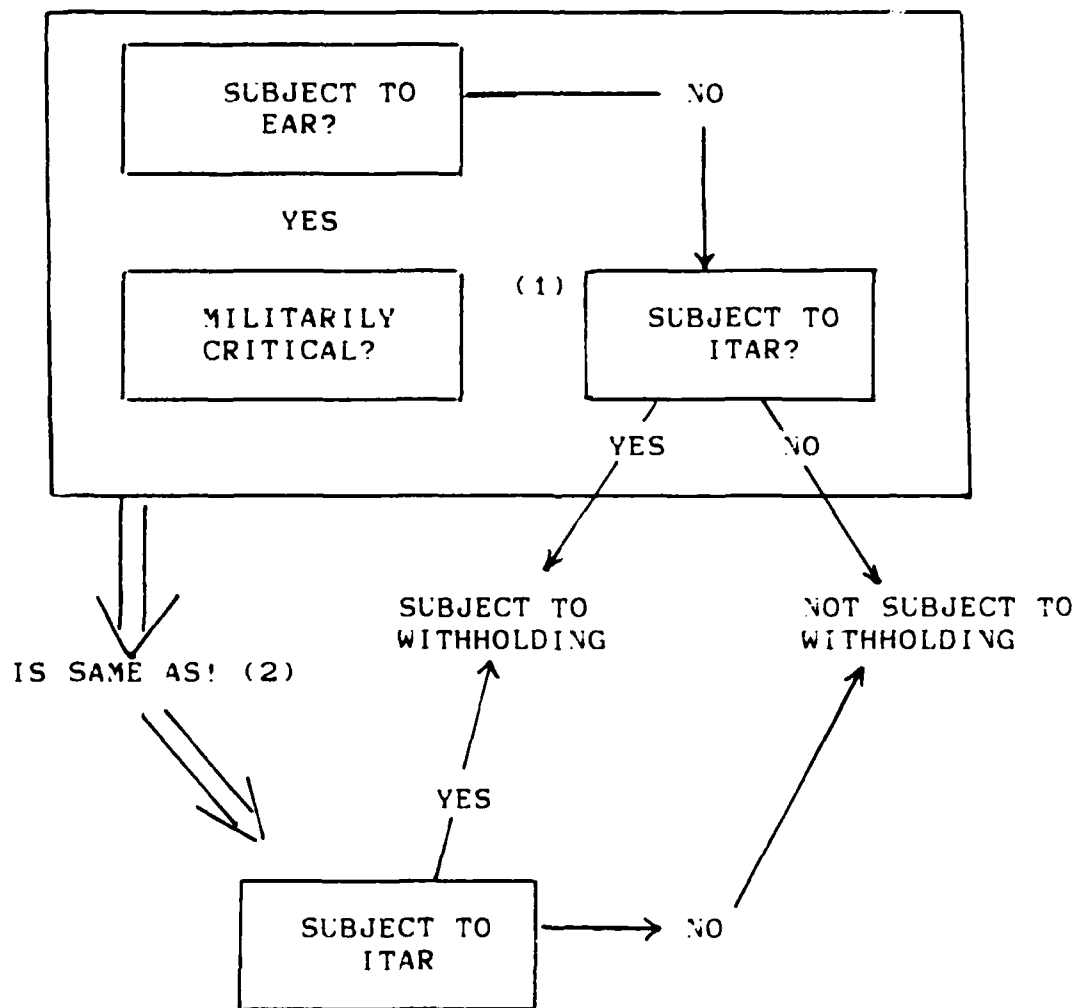
GUIDELINES FOR IMPLEMENTATION

As has been shown, there exist significant inconsistencies in the implementation by DOD of the export control laws and directives for structural materials research. This in turn is caused primarily by a lack of understanding of those directives and laws. It also appears that there are no useful written guidelines available specifically designed for structural materials research. (It will be shown that the MCTL, which is often thought of in this regard, does not serve this purpose.) Therefore, in order to draw conclusions about how the implementation actually used relates to what should be done, it is necessary to develop some guidelines as part of this study. Appendix B presents the author's examination of the regulations and directives interpreted for structural materials research. Figures 2 and 3 present a summary of that process. Before discussing the recommended guidelines, it must be stressed that this section represents the author's opinion and not a position officially sanctioned by DOD.

Based on the author's examination (See Appendix B for details.), the EAR was not considered pertinent to the control of structural materials research because it excludes scientific and engineering data. The ITAR, on the other hand is pertinent. However, for structural materials, this too is limited. Those regulations control structural materials technology only when it relates to a material being "specifically designed or modified for defense applications." (18:47688) Very few materials, especially in the research stage, fall into this category. One notable exception would be materials being developed for the National Aerospace Plane. (In actuality, much of this work is classified rather than controlled.) In this author's opinion, most other research would not be subject to ITAR unless it presents technology that would make a significant difference in one's ability to specifically design or modify a material for defense applications. This might include approaches for making a material to net shape, but certainly not the generic kind of processing information now being controlled. That kind of control is not in keeping with the intent of ITAR. It should also be noted that for structural materials the test for military criticality is implicit in the ITAR regulations. Thus, the existence of that technology in the MCTL is moot for a research program. For example, curing and pyrolysis of ceramic matrix composites is one of the "arrays of know-how" listed in the MCTL. (16:5-9) However, generic research on ceramic matrix composites which simply examines the effects on properties of various approaches to curing and pyrolysis would not, in this author's opinion, be controllable under ITAR.

There will be those who will disagree with this approach to the withholding decision. It still requires judgments be made by the contractor and the DOD program manager -- there is no

STRUCTURAL MATERIALS RESEARCH



NOTES: (1) MILITARILY CRITICAL IF AND ONLY IF SUBJECT TO ITAR

(2) THEREFORE, ITAR IS NECESSARY AND SUFFICIENT TEST FOR CONTROL OF STRUCTURAL MATERIALS RESEARCH

Figure 2. Summary of Proposed Evaluations Guidelines for Structural Materials Research

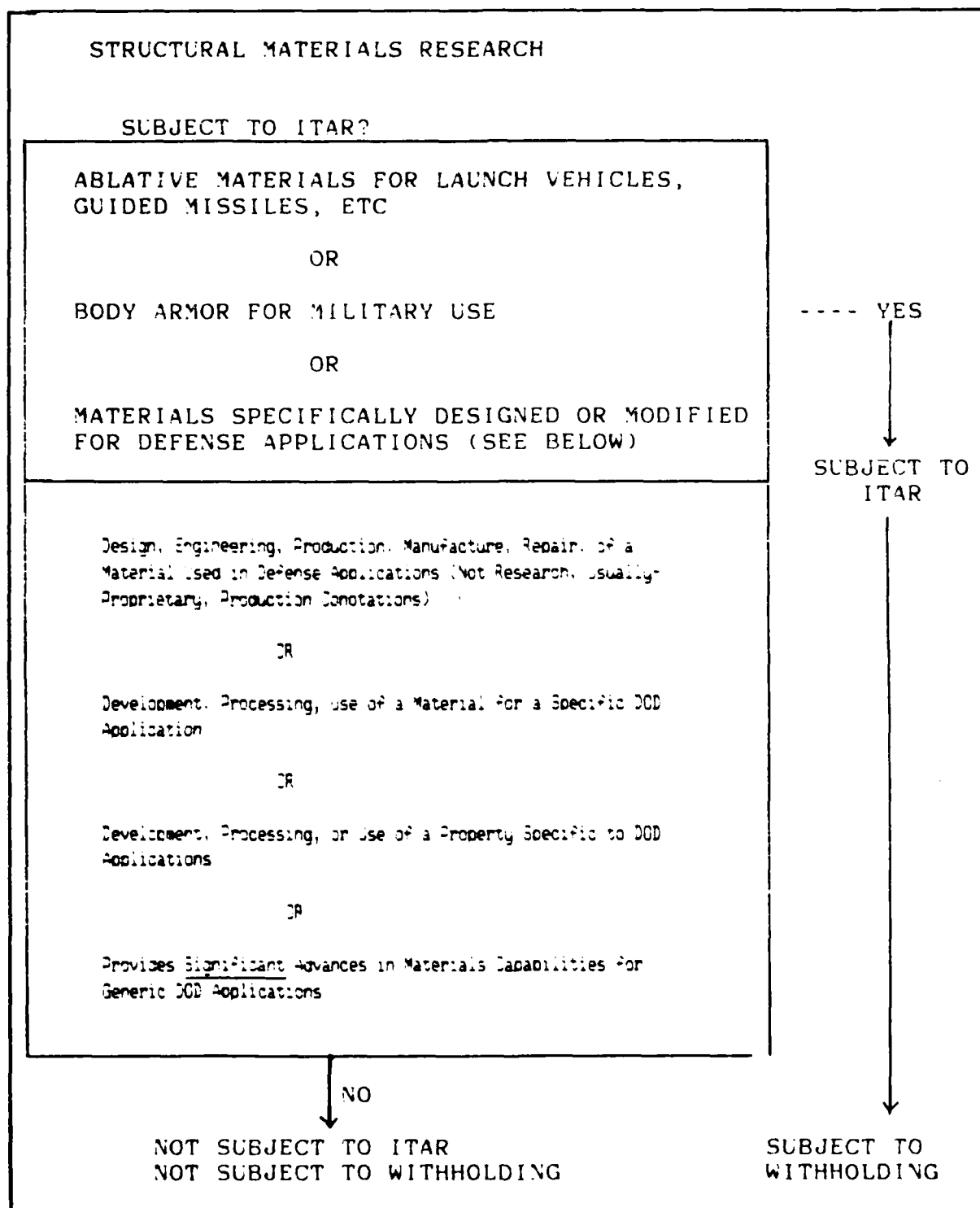


Figure 3. Proposed Guidelines for Control of Structural Materials Research Using the ITAR

escape from this. However, by controlling only significant information, that which would seem to be proprietary anyway, the greatest amount of scientific freedom could be maintained. There is of course a danger that the Soviets will gain some useful technology. This risk ought to be minimal. The Soviets are more often than not interested in techniques which will improve their own particular capabilities. (23:10) This kind of basic structural materials research data would be of little use to them. Furthermore, it is the linking of this data at the highest level which is critical. That information would still be export controlled at a minimum, and is often proprietary. Finally, this approach is consistent with the intent of DOD to keep critical information out of the hands of the "East". Richard Perle, Assistant Secretary of Defense for International Security Policy, a strong proponent of the export laws, said in a Senate subcommittee hearing that he would reduce the statement of military critical to one sentence: "embargo all exports of technology and commodities the transfer of which would have a significant impact on the military forces of the Soviet Union and her allies." (22:157) Although Perle does not think this is workable (22:157), this author disagrees. Note the word "significant". The criterion discussed above makes this exact test.

Chapter Four

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The implementation and interpretation of export control regulations and directives for structural materials research has not, and most likely will not, drastically affect the conduct of the research and its utility to DOD. Nothing in the data nor anything implied by those interviewed, indicated any insurmountable consequences. Most felt that the problems imposed were a minor inconvenience at best, a nuisance at worst.

That is not to say that the impact of export control on the field or individual research programs will be nonexistent. In fact, many of the problems uncovered could in time become more serious if not corrected. As discussed in Chapter Three, these problems are consistent with the general issues which have frequently been raised concerning control of scientific information. Ironically, the export control regulations per se do not appear to be the root of these problems. Rather, it is the way in which export control is implemented and interpreted by DOD specifically for structural materials research which appears to be responsible for most of the potential concerns.

The remainder of this section discusses the major conclusions regarding the implementation and interpretation of export control for structural materials research and the impact these have on the field. The conclusions reached about how the export control regulations are interpreted and implemented follow in a straight forward way from the findings (Table 5). The conclusions reached regarding the long term impact on structural materials research are, of necessity, more subjective in nature and, as shall be seen, result both from specific issues raised, and speculation on the long term effects of those specific issues. The major conclusions from this study are summarized in Table 7. It should be noted that many of the issues raised during the interviews (See Chapter Three.), while not considered major, could also impact the field.

1. Although the implementation and interpretation of export control as currently practiced is unlikely to have a drastically detrimental effect on structural materials research, there are several issues which could affect structural materials research.

a. Most program managers lack knowledge of the directives and regulations which form the basis for withholding.

b. The lack of knowledge and absence of guidelines has led to inconsistency in implementation.

c. The control exercised by DOD is more restrictive than required by the existing regulations and directives

d. The control exercised by DOD is generic in nature, and tends to categorize entire technologies as controlled.

2. The issues described above could lead to significant long term problems for the structural materials research.

a. Basic research could be hindered by the overly restrictive controls and the generic approach to control. Universities especially could be kept out of areas of interest to DOD. Professional societies might also be unnecessarily affected.

b. Certain technologies and/or companies could be hurt by the lack of communication with competitive foreign governments.

c. DOD's inconsistency could lead to an alienation of the basic research community.

Table 7. Summary of Conclusions

Implementation and Interpretation

It can be concluded that most DOD program managers lack knowledge of both the directives (DOD and/or service) governing the withholding of unclassified information and the export control regulations which form the basis for that withholding

authority. In addition, there are almost no guidelines being used to make export control decisions. In lieu of knowledge or guidelines, program managers use their own perceptions of what should and should not be withheld. This has led to significant inconsistencies in the implementation of the export control regulations and, as could be expected, to a great deal of confusion about what is and what is not controlled. The inconsistencies in the approaches to handling universities and basic (6.1) research is the most serious example.

It appears that the control exercised by DOD for structural materials research is not in keeping with the intent of the export regulations, but rather is overly restrictive. This is the perception of a majority of the program managers as well as the researchers. An examination by the author of the export control regulations (see Appendix B) confirms that very little of either basic or applied research in structural materials should be controlled. This is not currently the practice. In fact, many program managers ignore NSDD 189, leading to tighter control of basic (6.1) and university research than is in required.

The implementation of export control suffers from a generic approach in which entire technology areas (e.g. metal matrix composites, rapid solidification) are labeled as "subject to export control" and then, only by exception, is any technology in that subject area available for public dissemination. This approach probably comes from a lack of an ability and/or a lack of willingness on the part of DOD to make definitive statements about what should and should not be controlled. Because there are no guidelines nor detailed knowledge about what should and should not be controlled, this is the easy way out. Yet, as shall be seen, it is potentially quite detrimental.

Impact

The major long term impact of the implementation and interpretation of export control regulations on structural materials research is the unnecessary impediment to the flow of structural materials research information within the U.S. This most seriously affects basic research in general and university research in particular. Although the lack of knowledge and guidelines could have led program managers to under control of the technology, this has not happened. As seen above, NSDD 189 is largely ignored and technology is consistently over controlled. The generic labelling of areas as "controlled" coupled with over control could be especially hard on universities. In fact, universities could be "fenced" out of important areas. These factors also force professional societies to hold restricted sessions on entire technology areas.

Another related conclusion is that the U.S. research community will have increasing difficulties in dealing with competitive Western researchers. Here implementation, as currently practiced, often restricts the flow of technology to allied countries even if they are ahead of us. In addition, implementation impedes joint programs and, as pointed out by one researcher, comes at a time when these countries have used the U.S. technical data base for parity in structural materials and are now in a position to assist our research base. This problem will undoubtedly have a long term effect on those areas where foreign researchers can contribute. Ceramics and ceramic composites may be an example. Another effect is on professional societies which have to deal with foreign membership and universities which use foreign graduate students. Small U.S. companies are also hurt in their dealings with those Western countries because they are forced by the export laws to shield much of their technology. This may not be an issue for the research community. Also, there does not appear to be an effect on the larger U.S. companies which perform DOD research for enhancement of their own products. Whether they are affected in the long run remains to be seen.

It can also be concluded that the research community's perception of the lack of consistency in the implementation and interpretation of the regulations complicates all of the issues above. Although it is possible for the community to adapt to these inconsistencies, it is likely these inconsistencies will become more detrimental as time goes on. They make DOD look arbitrary in its implementation which might not only irritate researchers, but also might undermine their confidence that DOD is implementing these regulations for a distinct purpose - to prevent the flow of Western technology to the East. For example, researchers are aware of NSDD 189, but DOD consistently seems to ignore it. Also, researchers see papers presented in open sessions that seem to contain the same information as those papers forced into closed sessions. Although, no quantitative data can be cited to support this conclusion, it seems apparent to this author that there is an undercurrent of resentment which can only be bad for the field.

One other area for which a conclusion would be useful is in the filing of foreign patents. Unfortunately, the most which can be said is that this area is poorly understood. There was little knowledge about what can and cannot be published in patents, and what the exact meaning of a "secrecy" order is. A definitive conclusion on whether foreign patents are too restrictive or not restrictive enough could not be reached.

RECOMMENDATIONS

It is clear that DOD structural materials research is not being drastically altered by the way export control position is currently being implemented and one could take the position that "if it is not broken, don't fix it". However, the way export control is being applied is currently very inconsistent and arbitrary and thus, changes must be made to prevent any long term effects on the field. The following recommendations are therefore presented.

Recommendation I.

Develop simple, explicit guidelines for control that are consistent with the regulations and directives. A policy for basic (6.1) and university research should be developed and widely disseminated. These guidelines and policies should be implemented consistently throughout the field.

Based on an examination (See Appendix B and Chapter Three) performed by this author of those regulations and directives, it appears that only ITAR is applicable to materials research. Furthermore, ITAR controls only that data which would make a significant contribution to designing or modifying a material specifically for DOD application. Using that criterion, much of what is currently controlled would not be. Therefore, guidelines could be adopted which would provide more leeway for researchers while still remaining consistent with the letter and spirit of existing regulations and directives. Specifically, basic (6.1) and applied (6.2) research in structural materials would not be controlled unless the technical information would make a significant impact on DOD's use of the material. A way to think about this would be to consider only that information which might be proprietary and/or patentable to be subject to controls. Since basic research in structural materials would then not ordinarily be controllable, this would allow work at universities on interesting issues and also alleviate the problem which universities have with foreign graduate students. In addition such guidelines should aid in dealing with foreign researchers and assist the professional societies. It should be remembered that at some point, most usually late in the applied research phase, the research will begin to be specific enough that it would have the potential of falling under ITAR. If one is going to keep information from the Soviets, at some point the line must be drawn. The criteria presented in this study (Appendix B) seem a reasonable way to determine this point.

Other, perhaps more enlightened experts could be tasked with making more definitive guidelines, but some guidelines must be established and implemented consistently.

Recommendation II.

Clearly identify those parts of each technology which are subject to controls, and control only those parts.

In every technical area, even under a set of reasonably unrestrictive guidelines, there will be some controlled areas. It is important to keep those from being disseminated publicly. However, to categorize the entire technology (rapid solidification, metal matrix composites, etc.) as controlled defeats the purpose of having guidelines. This is much the same as classification. Reports, meetings, etc which contain classified information are restricted as appropriate, but it is always possible to tell what was and was not classified. Furthermore, it is often useful to conduct unclassified meetings on those generic areas to get input from the widest possible audience. Export control should be run that way. Controlled areas should be readily identified and restricted, but as much of every technology as possible should be available to the international research community. Using the classification system as a model, it might even be reasonable to assign dates after which a report withheld from public dissemination would be automatically released. This would prevent the administrative nightmare of having to request release of documents which cover outdated technology.

Recommendation III.

Educate program managers and others making technical decisions about withholding.

Regardless of the fate of the above recommendations, it is unacceptable for decision makers to be as ill-equipped to make decisions as they currently are. This includes not only knowledge about the guidelines for withholding, but also understanding the intricacies of foreign patents and the ramifications or secrecy orders. (Authors note: the patent issue has now been addressed by OSD and the patent office and new rules have been published.) (30:--)

The recommendations of this study are purposely aimed at DOD and indicate a need for program managers and others to learn the requirements of the laws and directives and then make some definitive decisions about what should be controlled. This author believes that if this is done properly, the guidelines will be less restrictive, but still serve their function. The researcher community, however, still has a role to play. It is

incumbent upon researchers to learn the general provisions of those guidelines and to help DCD determine the significance of the research. With this knowledge, it would also be possible for researchers to help maintain the flow of scientific information themselves simply by removing from their presentations and/or papers any sensitive information (e.g. specific military applications). This author believes cooperation between DOD and the researchers is essential for making export control work for structural materials research.

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APPENDICES

APPENDIX A

THE WHITE HOUSE

WASHINGTON

September 21, 1985

NATIONAL SECURITY DECISION
DIRECTIVE 189

NATIONAL POLICY ON THE TRANSFER OF
SCIENTIFIC, TECHNICAL AND ENGINEERING INFORMATION

I. PURPOSE

This directive establishes national policy for controlling the flow of science, technology, and engineering information produced in federally-funded fundamental research at colleges, universities, and laboratories. Fundamental research is defined as follows:

"'Fundamental research' means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons."

II. BACKGROUND

The acquisition of advanced technology from the United States by Eastern Bloc nations for the purpose of enhancing their military capabilities poses a significant threat to our national security. Intelligence studies indicate a small but significant target of the Eastern Bloc intelligence gathering effort is science and engineering research performed at universities and federal laboratories. At the same time, our leadership position in science and technology is an essential element in our economic and physical security. The strength of American science requires a research environment conducive to creativity, an environment in which the free exchange of ideas is a vital component.

In 1982, the Department of Defense and National Science Foundation sponsored a National Academy of Sciences study of the need for controls on scientific information. This study was chaired by Dr. Dale Corson, President Emeritus of Cornell University. It concluded that, while there has been a significant transfer of U.S. technology to the Soviet Union, the transfer has occurred through many routes with universities and open scientific communication of fundamental research being a minor contributor. Yet as the emerging government-university-industry partnership in research activities continues to grow, a more significant problem may well develop.

III. POLICY

It is the policy of this Administration that, to the maximum extent possible, the products of fundamental research remain unrestricted. It is also the policy of this Administration that, where the national security requires control, the mechanism for control of information generated during federally-funded fundamental research in science, technology and engineering at colleges, universities and laboratories is classification. Each federal government agency is responsible for: a) determining whether classification is appropriate prior to the award of a research grant, contract, or cooperative agreement and, if so, controlling the research results through standard classification procedures; b) periodically reviewing all research grants, contracts, or cooperative agreements for potential classification. No restrictions may be placed upon the conduct or reporting of federally-funded fundamental research that has not received national security classification, except as provided in applicable U.S. Statutes.

Ronald Reagan

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APPENDIX B

RECOMMENDED GUIDELINES FOR EXPORT CONTROL APPLIED TO STRUCTURAL MATERIALS RESEARCH

As was shown in Figure 1 (See Chapter Two.), deciding whether technical data can be withheld requires an affirmative answer to a series of questions. It shall be assumed that the first two questions have been so answered. In other words, the information is in control of DOD and it has potential military or space application. Almost all DOD funded research meets these criteria. The next step is to determine if the information would be subject to export control. This means it must be a controlled technology according to either the Export Administration Act or the Arms Export Control Act. The controlling regulations for these are the Export Administration Regulations (EAR) and the International Traffic in Arms Regulations (ITAR) respectively. Each regulation also has general exclusions which must be considered. These exclusions were included in the DOD regulation on withholding (DODD 5230.25).

CONTROL BY EAR

Items to be controlled by the EAR are included on the Commodity Control List (CCL). This is primarily a list of items and dollar values above which these items may not be exported without a license. Included on this list are a great many items of interest to those involved in structural materials research including high strength fibers and organometallic precursors. More germane to the issue of withholding information in structural materials research is the specific control of shipments of certain technical data relating to:

- a. Production of superalloys including melting, remelting, or degassing techniques and the production in crude and semi-crude form.
- b. Composites using the strong fibers which are themselves export controlled. This includes processing conditions and procedures for regulating temperature and atmosphere.

c. Inert gas and vacuum atomization technology to control sphericity and uniformity in size. (19:12678)

Based on the above items, it would appear that all data on superalloys, rapid solidification, and composites of all kinds should be controlled. However, one of the general exclusions of the EARs (as cited in the DOD directives) is for scientific or educational data which are "not directly and significantly related to design, production, or utilization in industrial processes." (emphasis added) (12:3-1) These are the same terms used in NSDD 189 to distinguish basic and applied research -- information which is normally shared, from that which is of a proprietary nature -- information not normally shared. In other words, the spirit of the EAR is the same as NSDD 189 and any data which is scientific or educational, i.e. not considered proprietary, falls under the general exclusion and the EAR cannot be cited as a reason for withholding.

CONTROL BY ITAR

The interpretation of ITAR is more complicated. In addition to making the export of any "defense item" subject to review, ITAR also controls "technical data relating to the design, engineering, development, production, processing, manufacture, use, operation, overhaul, repair, maintenance, modification, or reconstruction of defense item." (18:47686) Also note that ITAR contains no general exclusion exempting scientific and technical data. In the regulation, "defense item" turns out to be almost anything one could think of including ammunition, projectiles, land vehicles, aircraft, engines, spacecraft, etc. Here structural materials are specifically mentioned as "defense items" in several contexts. Two are fairly specific; they are paraphrased below: (18:47686-47687)

CATEGORY IV - Launch Vehicles, Guided Missiles, Rockets, etc.

(f) ablative materials fabricated or semi-fabricated from advanced composites (e.g. carbon/carbon) when specifically developed or modified for this category.

CATEGORY X - Protective Personnel Equipment

(a) body armor specifically designed, modified or equipped for military use.

The final category in which structural materials is mentioned is CATEGORY XII - Auxiliary Military Equipment as follows:

armor plate and structural materials (including but not

limited to plate rolled and extruded shapes, bars and forgings, castings, welding consumables, carbon/carbon or metal matrix composites) specifically designed or modified for defense articles. (18:47688)

The first two categories listed above are unambiguous and consequently any technical information relating to either ablative materials or military body armor is subject to export control. But what of the final category? This restriction is very general and makes ITAR potentially applicable to all technical information relating to structural materials. However, in this case, the key is the phrase: specifically designed or modified for defense articles. Technical information is only controlled if it relates (i.e. gives information on design, processing, use, etc) to structural materials which have a specific association with defense articles. Therefore, making a decision about whether information is subject to export control requires one to decide the issue of how closely a material is connected to DOD application or whether the information significantly advances the capability of the material to be used in a DOD application.

For most of the materials development efforts related to production for DOD this association is clearly there. If one examines the terms connecting technical data to defense items, most (design, production, manufacture, etc.) already connote specificity to a part or at the least to developing a form or shape with properties useful to DOD system. Such information should be withheld. However, it is likely this kind of information is proprietary and/or classified and, in any case, is seldom applicable to research. In addition, there is a class of research which may be very basic, but is directly tied to a specific system. Development of alloys for the National Aerospace Plane is one example of this. Finally, there are efforts to improve properties which are inherently military in nature such as the resistance of a material to damage from a laser. In these cases as well, the material is being designed or modified for defense applications and technical information relating to that material is subject to control.

For the case of research, however, the bulk of technical information does not fit those special cases, but rather involves structural materials which are being developed for their potential to provide solutions to generic military requirements or problems. An example might be the generic need for high temperature materials for high performance turbine engines. It is the author's belief that even a strict reading of ITAR would conclude that, if a material is being developed as a generic solution to a military requirement, technical information relating to that material should only be controlled if it makes a significant impact on the capabilities of that material to solve the problem. This is the only kind of

information which would ultimately connect the design or modification of a generic material directly to a DCD application. In other words, control should only be placed on information which would normally be patentable or proprietary anyway. For example, relating variations in processing conditions (e.g. temperature, pressure) of a composite being developed as a high temperature material, and relating it to generic properties (thermal stability, toughness, etc.) should not be withheld, nor should a discussion of the generic application. What would be critical, and thus subject to withholding, would be how these approaches might translate to manufacturing.

MILITARY CRITICALITY

The final step in the withholding decision is to examine technology which is subject to export control to see if it is militarily critical technology. In fact this step is really moot. From above it can be seen that structural materials research cannot be subject to export control unless it is subject to ITAR or EAR. And if it is subject to ITAR, it is, in the case of structural materials, the same as saying it is militarily critical. In the case of those technologies specifically itemized in the EAR, they too would be subject to ITAR if they were militarily critical. Consequently, in this author's opinion, whether a particular structural materials research would be controlled under ITAR is a necessary and sufficient condition for withholding that information from public dissemination. That document requires the technology to relate to a material specifically designed or modified for a defense application. Very little structural materials research falls in that category.

SUMMARY OF APPENDIX

The above discussion has taken the reader through a complicated thought process on the control of structural materials research. However, for the case of structural materials, whether a technology is subject to ITAR is necessary and sufficient for making the material subject to withholding under DOD directive 5230.25. Chapter Three, including Figures 2 and 3, summarizes the details of the withholding decision for structural materials research.

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